

CSE/STAT 416

Course Wrap Up

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University of Washington

June 2, 2021



Administrivia

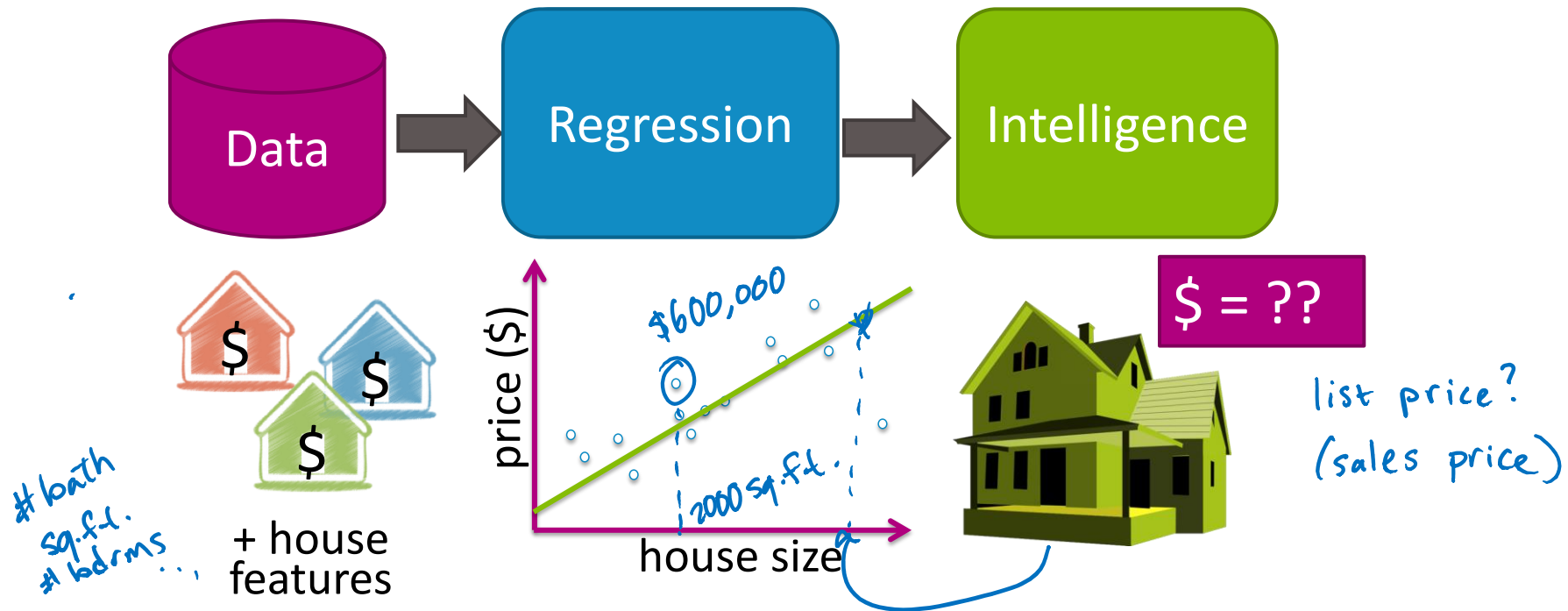
- Final Exam
 - Monday 8:30 am – Wednesday 8:30 am
 - Open note and open internet, but don't have someone else solve problems for you
 - Can be taken as a group (submit together on Gradescope)
 - No OH or help with review/conceptual questions during the exam. Help available on EdStem for clarification or logistic questions only.
 - Extra OH this weekend to help review
- Learning Reflection: Reminder that this week's learning reflection is a mind map instead of the usual format!
- One last checkpoint for today's class (if necessary), due on Monday like our normal schedule
- **Please fill out the course evals!**

One Slide

- Regression
- Overfitting
- Training, test, and generalization error
- Bias-Variance tradeoff
- Ridge, LASSO
- Cross validation
- Gradient descent
- Classification
- Logistic regression
- Bias / Fairness
- Decision trees
- Boosting
- Precision and recall
- Nearest-neighbor retrieval, regression, and classification
- Kernel regression
- Locality sensitive hashing
- Dimensionality reduction, PCA
- k-means clustering
- Hierarchical clustering
- Unsupervised v. supervised learning
- Recommender systems
- Matrix factorization
- Coordinate descent
- Neural networks
- Convolutional neural networks
- Transfer learning for deep learning



Case Study 1: Predicting house prices



Regression

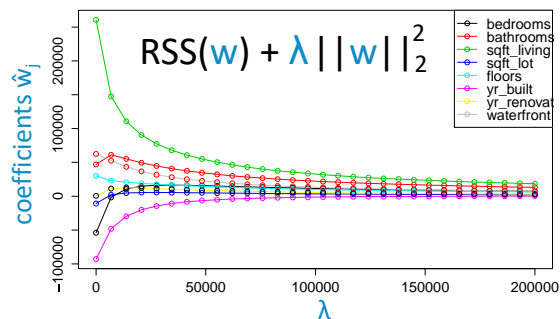
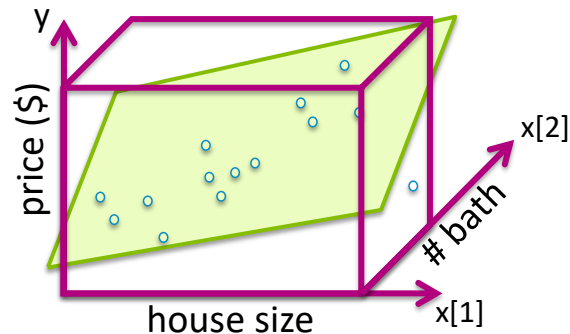
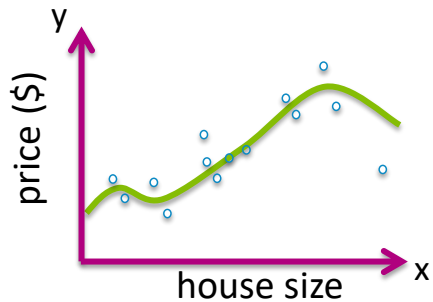
Case study: Predicting house prices

Models

- Linear regression
- Regularization: Ridge (L2), Lasso (L1)

Including many features:

- Square feet
- # bathrooms
- # bedrooms
- Lot size
- Year built
- ...



Regression

Case study: Predicting house prices

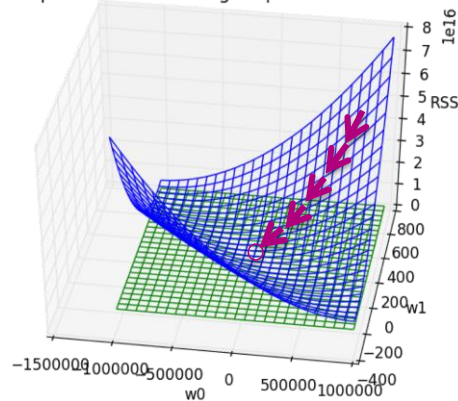
Algorithms

- Gradient descent

$$\begin{aligned} \text{RSS}(w_0, w_1) = & (\$_{\text{house 1}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 1}}])^2 \\ & + (\$_{\text{house 2}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 2}}])^2 + \\ & (\$_{\text{house 3}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 3}}])^2 + \dots \\ & \text{[include all houses]} \end{aligned}$$



3D plot of RSS with tangent plane at minimum

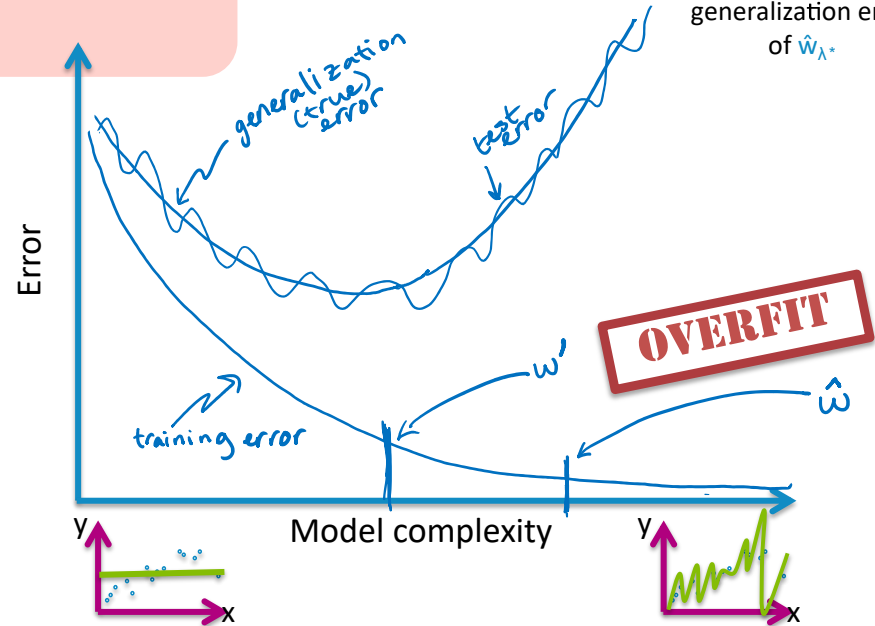
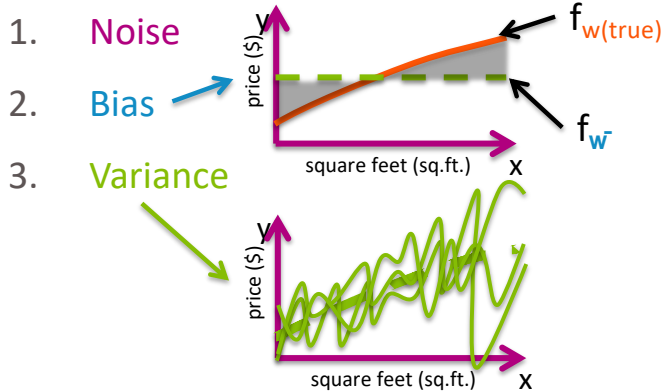
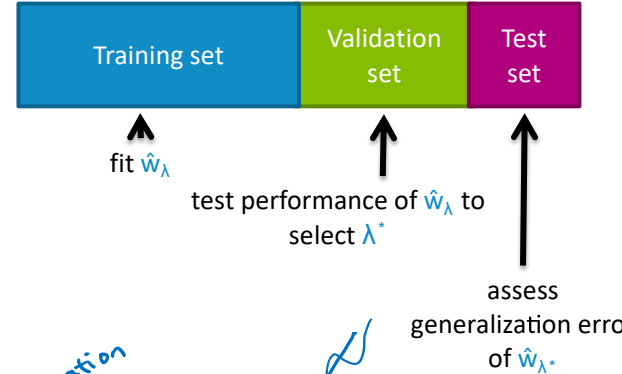


Regression

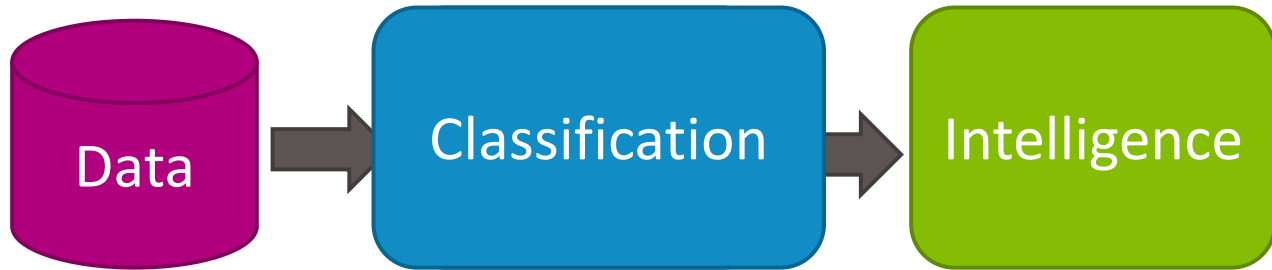
Case study: Predicting house prices

Concepts

- Loss functions, bias-variance tradeoff, cross-validation, sparsity, overfitting, model selection



Case Study 2: Sentiment analysis



Sushi was awesome,
the food was awesome,
but the service was awful.

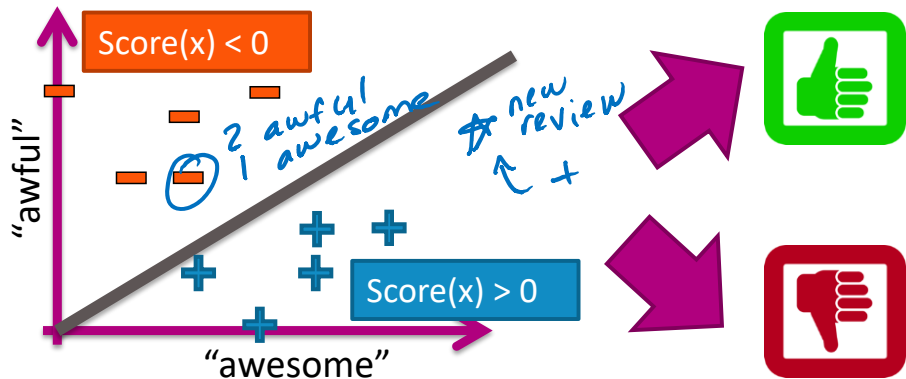
stars / +/-
→
text
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All reviews:

★★★★★ 7/21/2015
This is probably my favorite place to eat Japanese in Seattle. My boyfriend and I ordered nigiri of scallop, Japanese snapper (seasonal), and the agedashi tofu and 2 special rolls. I would skip the special rolls, because the nigiri and sashimi cuts is where this place excels. The tofu, as recommended by other Yelpers was amazing. It's more chewy and the sauce/gravy is the perfect amount of flavor for the delicate tofu.

★★★★★ 6/11/2015
Dining here at the sushi bar made me feel like sitting front row to an amazing performance. We didn't have resos, banged down to the ID after work, got here breathlessly at 5:10pm, and got the last two seats in the place.

★★★★★ 6/9/2015
I came here having high expectations due to the reviews of this place, but I was bit disappointed. The restaurant is small so do make reservations when you come here. Dishes cost from \$4-26 each and dishes are small.

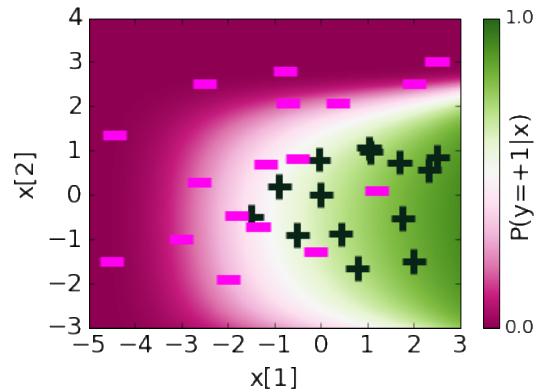
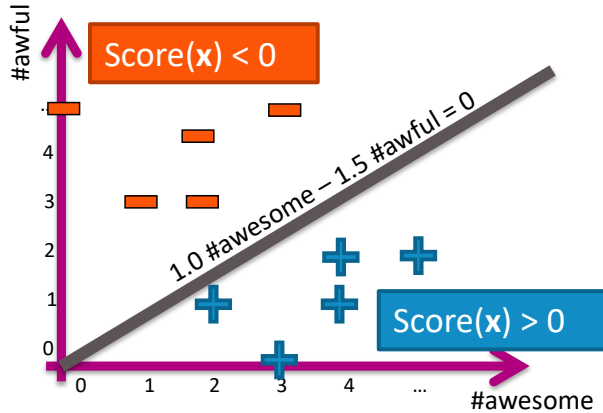
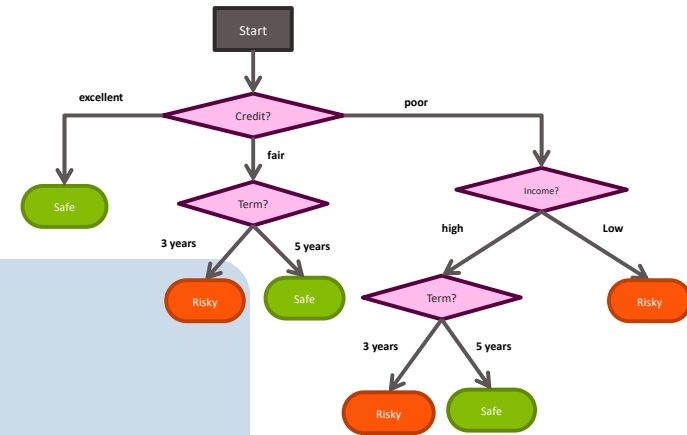


Classification

Case study: Analyzing sentiment

Models

- Linear classifiers (logistic regression)
- Multiclass classifiers
- Decision trees
- Boosted decision trees and random forests

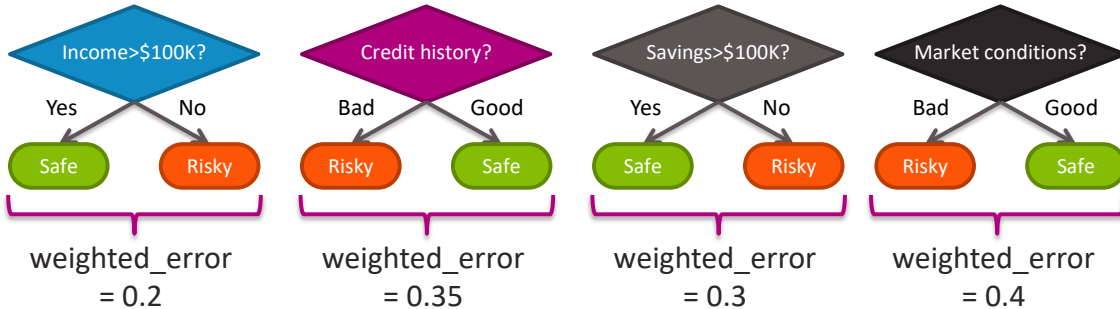
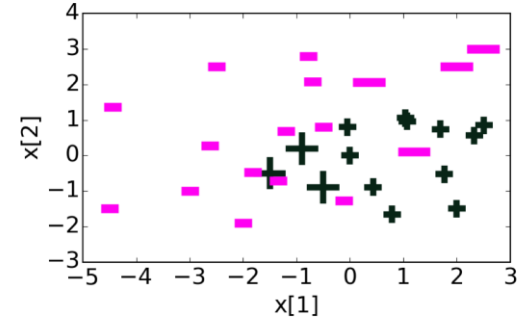


Classification

Case study: Analyzing sentiment

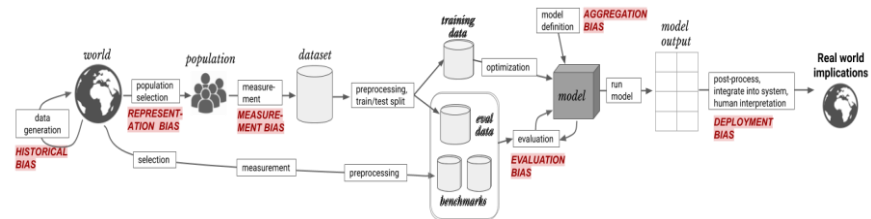
Algorithms

- Boosting
- Learning from weighted data



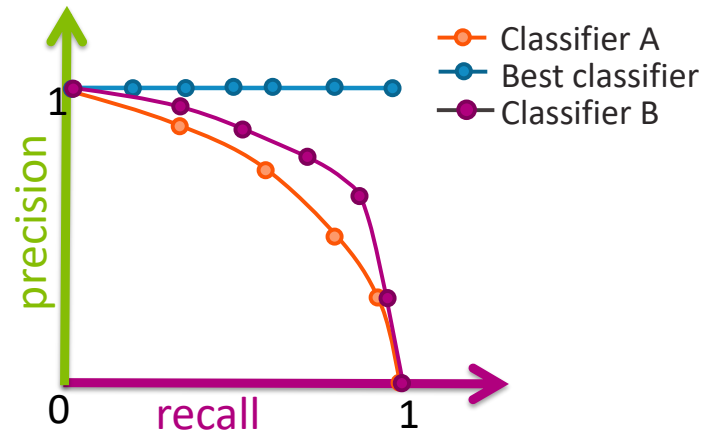
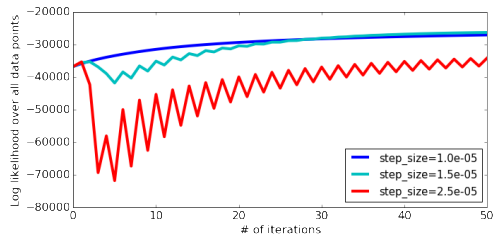
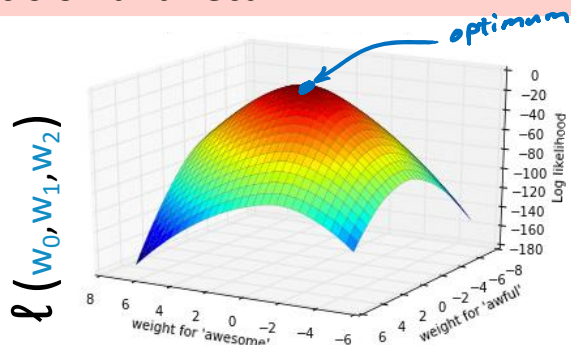
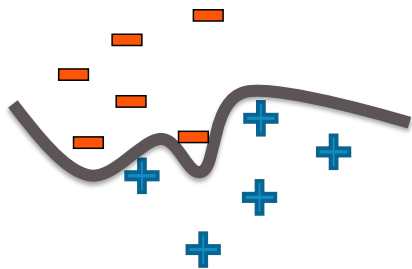
Classification

Case study: Analyzing sentiment



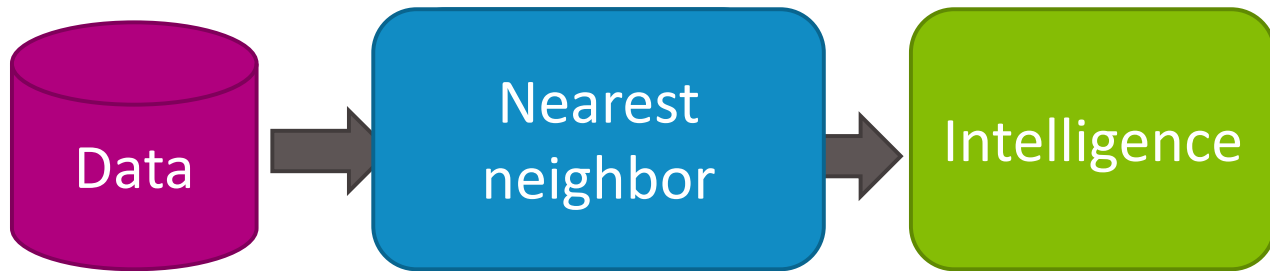
Concepts

- Decision boundaries, maximum likelihood estimation, ensemble methods, random forests
- Precision and recall



Case Study 3:

Document retrieval

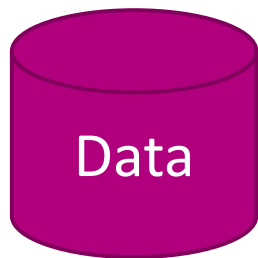


Case Study 3+:

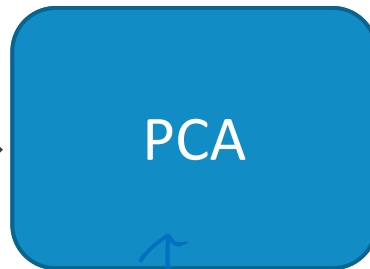
Document structuring for retrieval



Case Study 3++: Dimensionality reduction

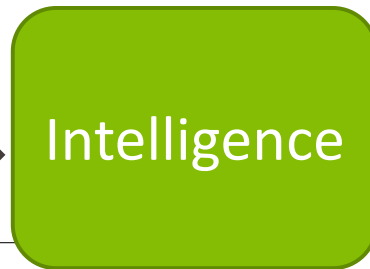


Data

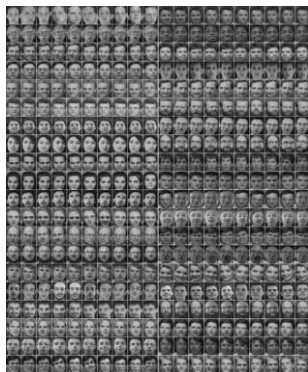


PCA

simple

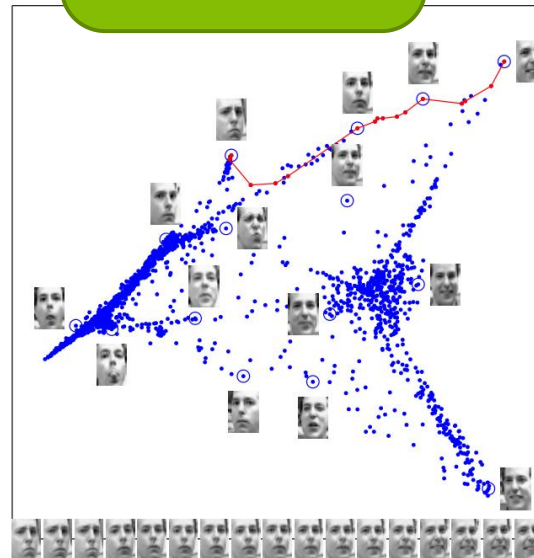


Intelligence



Images with
thousands or
millions of pixels

Can we give each
image a coordinate,
such that similar
images are near each
other?



[Saul &
Roweis '03]

Clustering & Retrieval

Case study: Finding documents

Models

- Nearest neighbors
- Clustering
- Hierarchical clustering



SPORTS



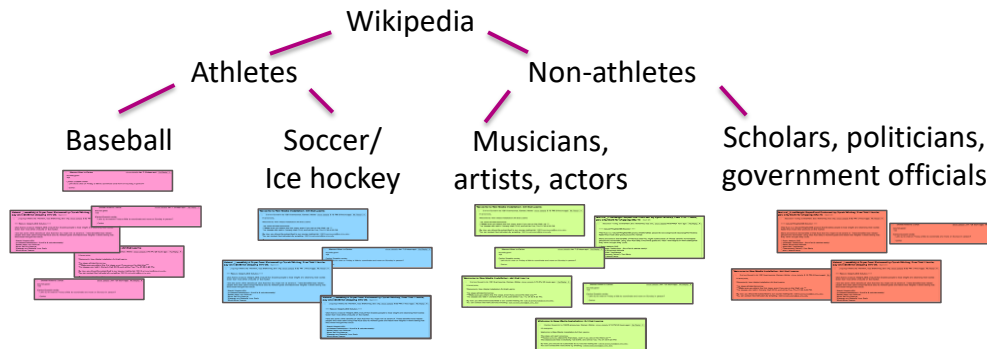
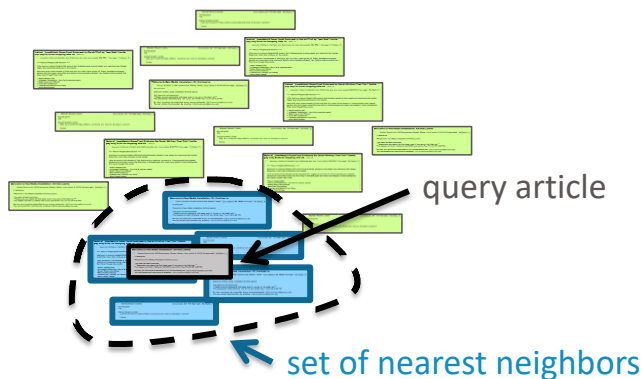
WORLD NEWS



ENTERTAINMENT



SCIENCE



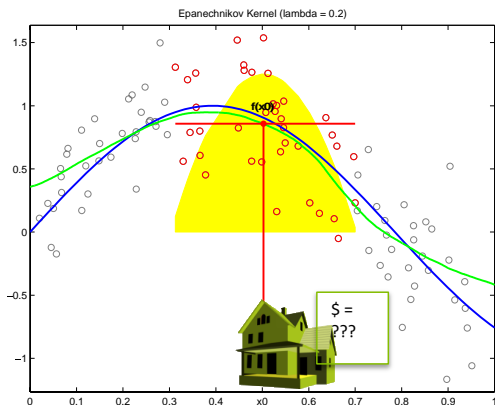
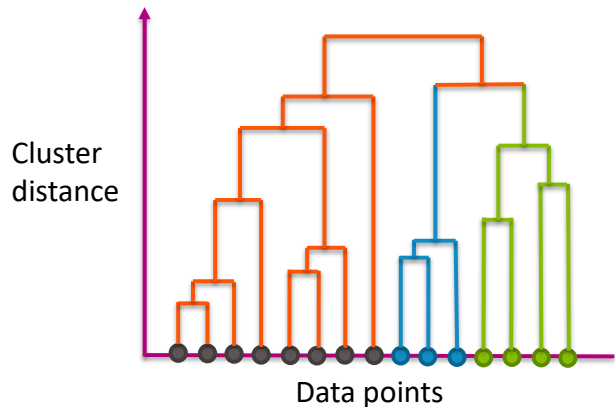
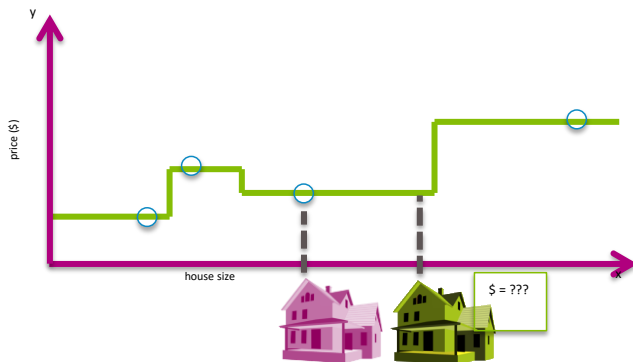
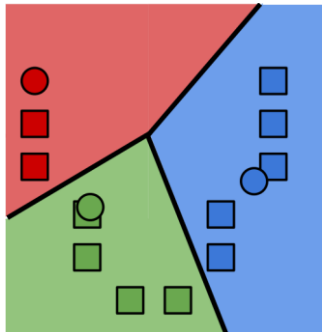
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Clustering & Retrieval

Case study: Finding documents

Algorithms

- k-means
- Locality-sensitive hashing (LSH)
- NN regression and classification
- Kernel regression
- Agglomerative and divisive clustering
- PCA

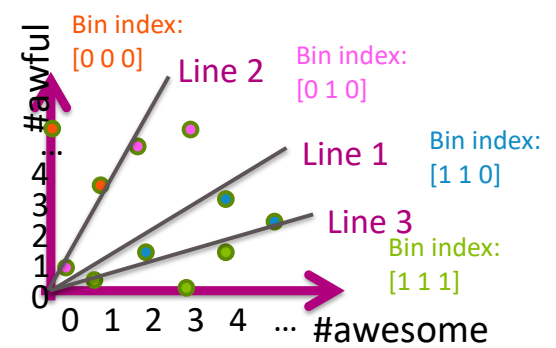
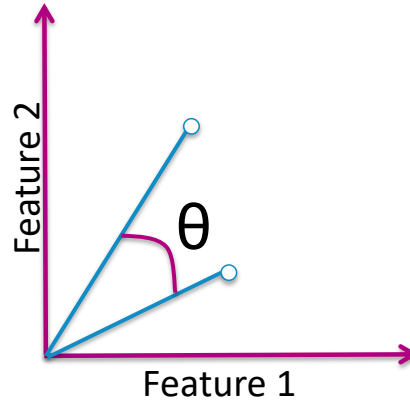
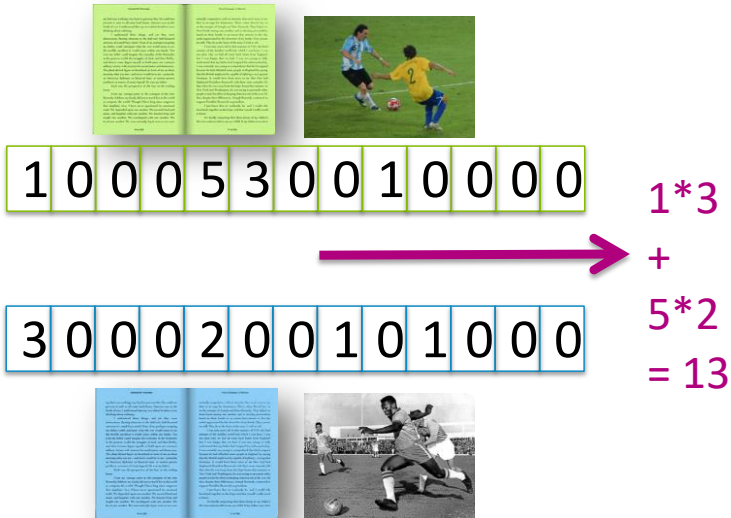


Clustering & Retrieval

Case study: Finding documents

Concepts

- Distance metrics, kernels, approximation algorithms, dimensionality reduction



Principal components:



Reconstructing:



Case Study 4: Product recommendation

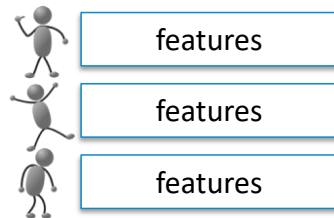


Your past purchases:



+ purchase histories
of all customers

Customers



Products



Recommended items:



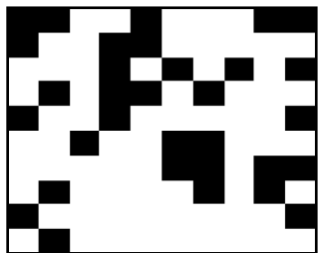
Recommender Systems & Matrix Factorization

Case study: Recommending Products

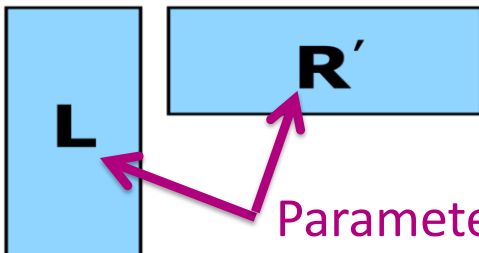
Models

- Collaborative filtering
- Matrix factorization

Rating =



\approx



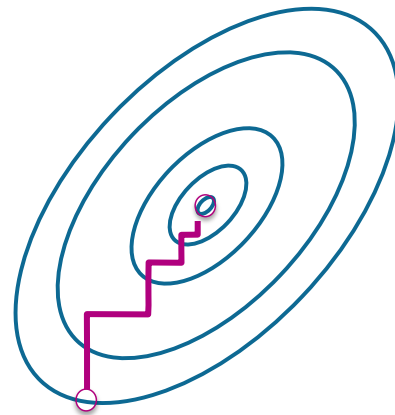
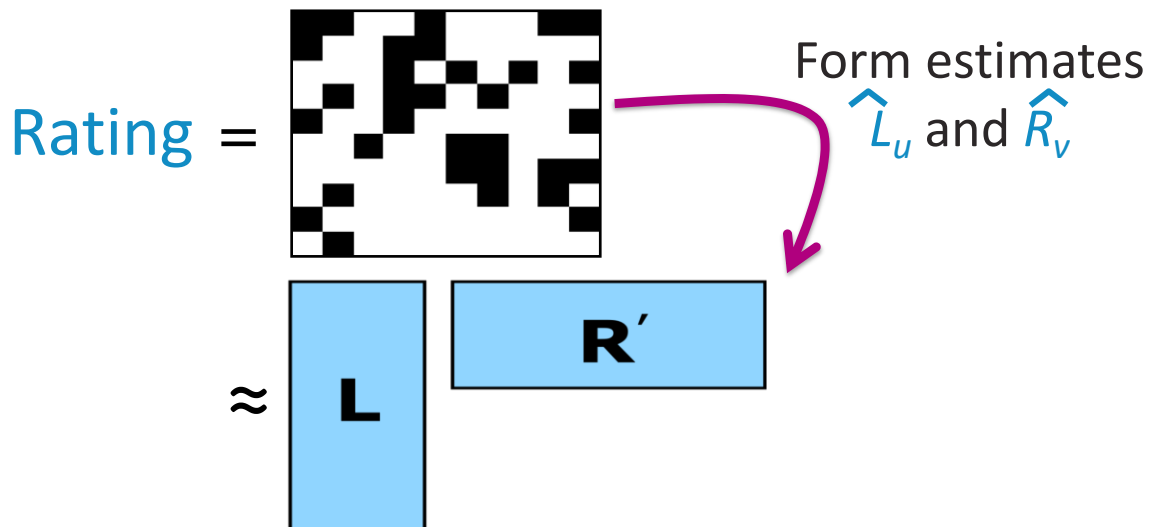
Parameters of model

Recommender Systems & Matrix Factorization

Case study: Recommending Products

Algorithms

- Coordinate descent

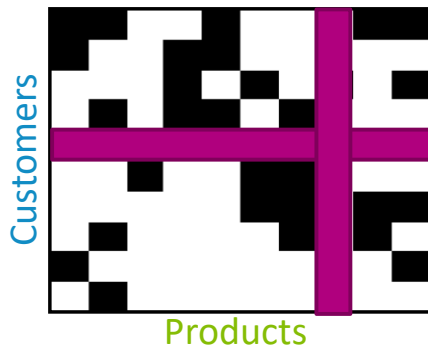
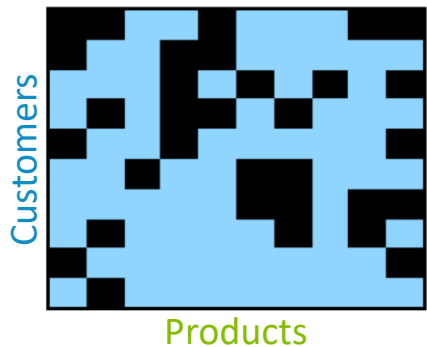


Recommender Systems & Matrix Factorization

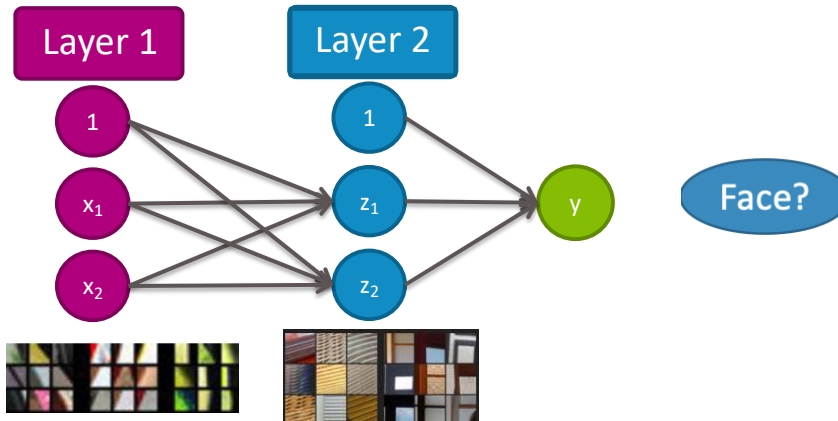
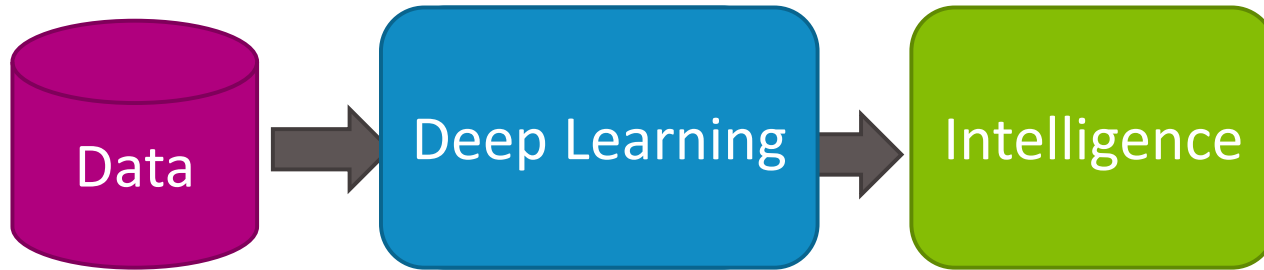
Case study: Recommending Products

Concepts

- Matrix completion, cold-start problem



Case Study 5: Image classification

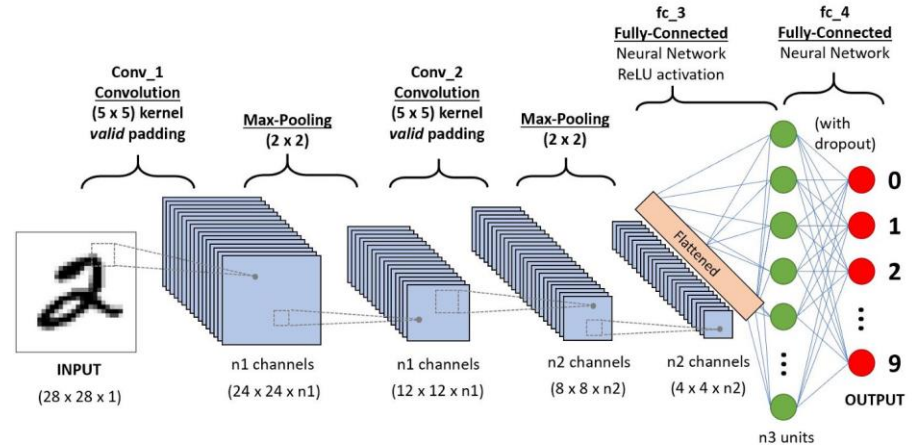
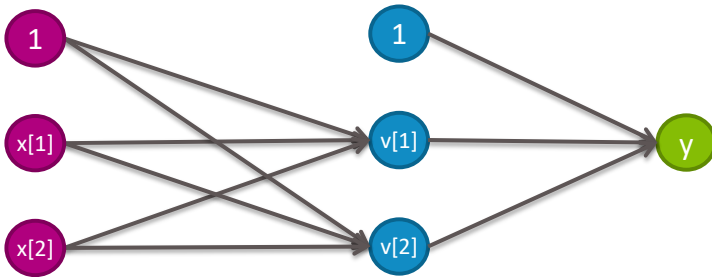
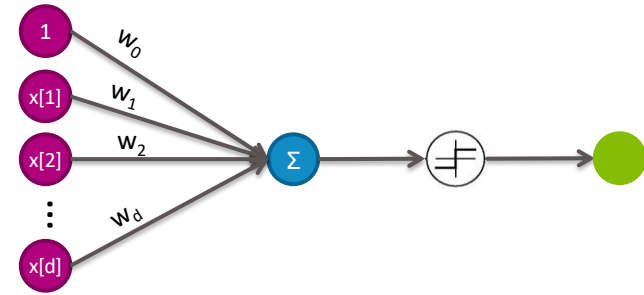


Deep Learning

Case study: Image classification

Models

- Perceptron
- General neural network
- Convolutional neural network

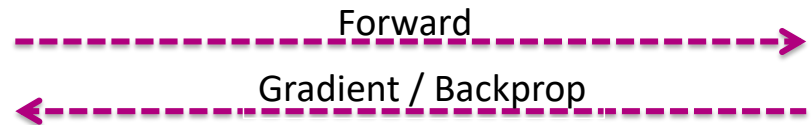
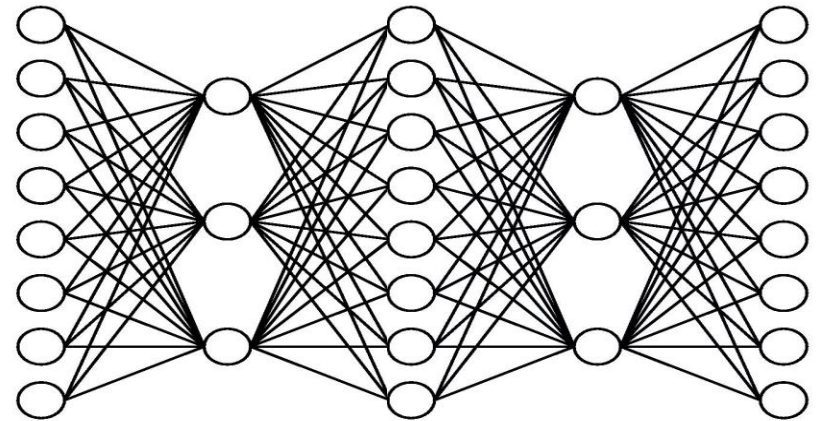
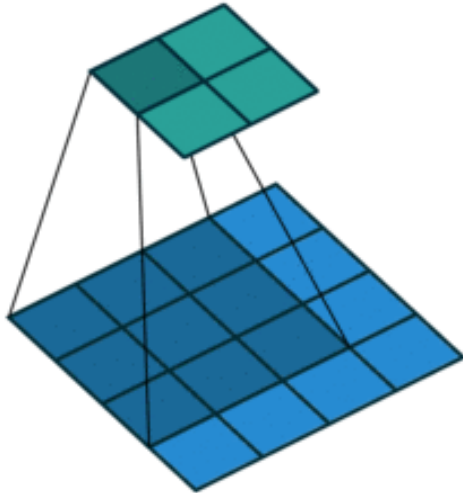


Deep Learning

Case study: Image classification

Algorithms

- Convolutions
- Backpropagation (high level only)

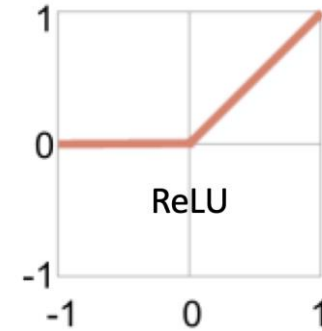
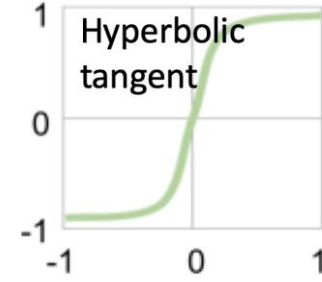
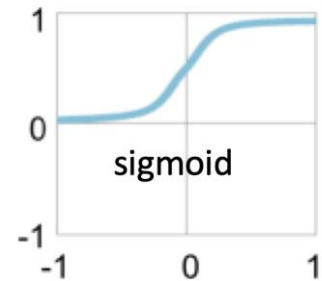
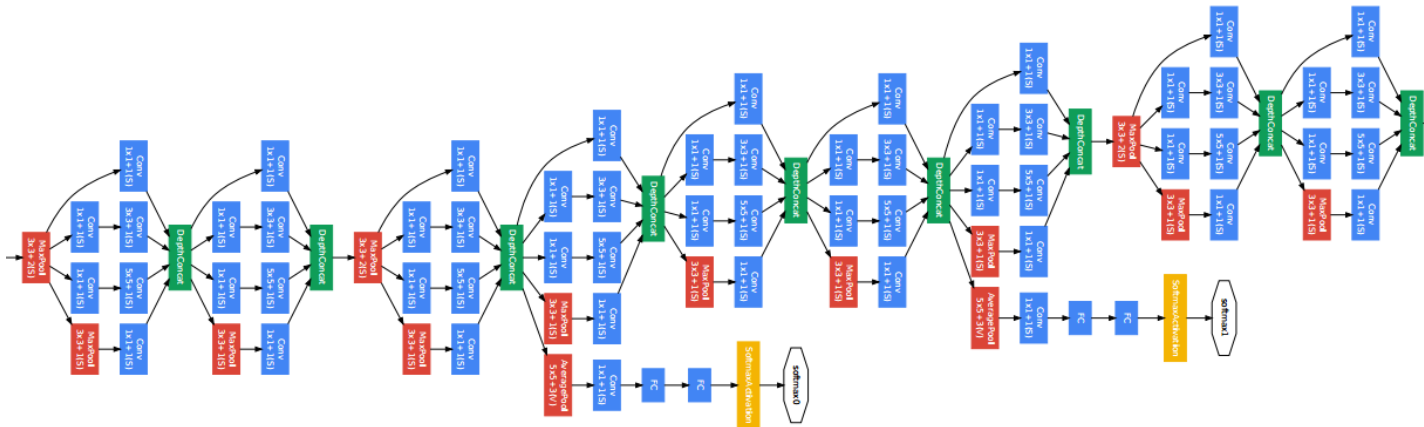
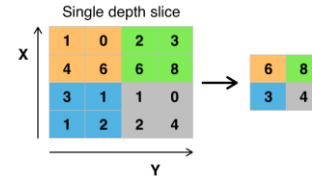
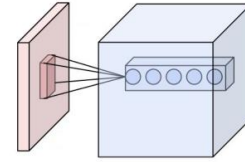


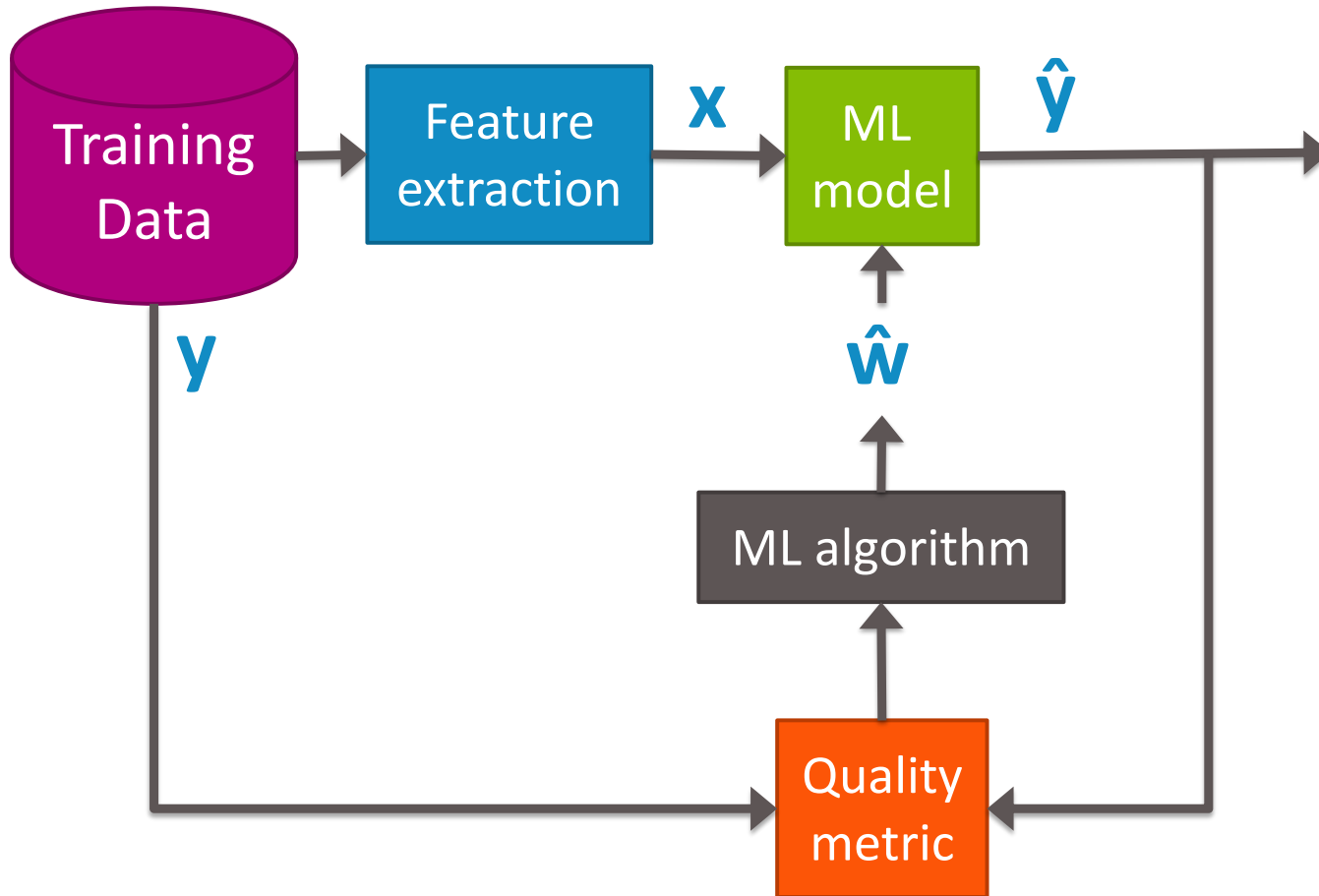
Deep Learning

Case study: Image classification

Concepts

- Activation functions, hidden layers, architecture choices







Brain Break



Poll Everywhere

Think 

2 min

pollev.com/cs416

Tomorrow's quiz section will be Q&A review sessions. You bring questions and your TA will review concepts and discuss with your section.

To help them do a little prep please fill out this PollEverwhere question outlining some topics or questions you would want them to go over in section.

Free response box, but please put your section at the beginning (e.g., "Section AF: I would want to go over matrix factorization").

This poll will be open all day today, but will close tonight.

Future Directions

Classes

There isn't a clear, "one right class" to take next! If you want to take course work, you can take anything that you are interested in to apply your ML knowledge there!

Fairly comprehensive list of data science class at UW:

<https://escience.washington.edu/data-science-courses-at-the-university-of-washington/>



Future Directions

This is a (very insufficient) attempt to outline some interesting directions ML research is going. This list fails to provide breadth of coverage and depth of all the ways ML can be applied.

Something not showing up in this list doesn't mean ML can't be used for that task! I'm just one opinion about what I'm excited about in ML!



FAccT

How do we make ML systems that don't cause harm when interacting with complicated, human systems.

ACM Conference on Fairness, Accountability, and Transparency

- Fairness: How to define and ensure fairness
- Accountability: Law and policy, metrics and audits
- Transparency: Interpretable and explainable models
- Privacy and Security: Privacy-preserving models, federated learning
- Human-ML Interaction: Humans in the loop, UX design, community designed systems, education



ML Systems

Construed broadly, trying to build systems to efficiently implement ML models.

- Hardware: TPU (Google)
- Energy Efficiency:
 - Green AI
 - TinyML
- Distributed Systems: Cloud software



ML Theory

Building foundational understanding for why/how ML works.

- Learning Theory (sample complexity)
 - Understanding Machine Learning (Shalev-Shwartz and Ben-David)
- Theory of Deep Learning
- Optimization (convex and non-convex)
- And more!



Applied ML

ML applied to basically any problem we might care about (and the tough challenges that come with that)

- Natural Language Processing (NLP)
- Computer Vision
- Computational Biology
- Medical Imaging / Health
- More



Big Picture

Improving the performance at some task through experience!

- Before you start any learning task, remember fundamental questions that will impact how you go about solving it

What is the learning problem?

From what experience?

What model?

What loss function are you optimizing?

With what optimization algorithm?

Are there any guarantees?

How will you evaluate the model?

Who will it impact and how?



Congrats on finishing CSE/STAT 416!
Thanks for the hard work!

